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University of Kentucky

**LEAFHOPPER INJURY TO CLOVER AND
ALFALFA**

BULLETIN NO. 293



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BULLETIN NO. 293

Leafhopper Injury to Clover and Alfalfa*

By H. H. JEWETT

During certain of the seasons in which clover and alfalfa fail to make satisfactory growth, the plants are more or less dwarfed and unthrifty in appearance, the leaves of alfalfa being yellow in color, and those of clover, yellow, pink, red or brown. This condition of the plants is not present in the early spring but may appear before the first cutting or soon after the first cutting and becomes more noticeable as the summer advances, but disappears in the fall.

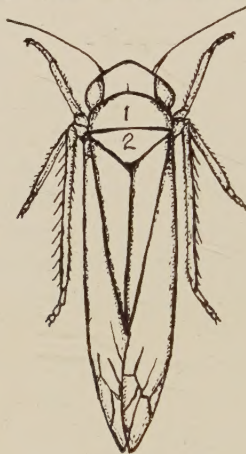
The dwarfing of clover and alfalfa and the discoloring of the leaves of these plants were attributed, by different investigators, to various causes such as sun scald, physiological conditions of the plants, root diseases, soil conditions, unbalanced soil fertility, weather conditions, and other causes. Attempts were made also to isolate a causal organism from the affected parts of the plants, but no organism has been found to be generally associated with this particular condition of the plants.

CLOVER AND ALFALFA INJURED BY THE LEAFHOPPER, EMPOASCA FABAE

In the summer of 1926, E. A. Hollowell, John Menteith, Jr., and W. P. Flint, at the University of Illinois, observed a tip and marginal burning of clover leaves and also the yellowing of leaves and dwarfing of the plants. They observed, also, that the plants were infested with leafhoppers, mainly the potato leaf-

*The work reported upon in this bulletin was undertaken at the suggestion of the Department of Agronomy and has as its object the evaluation of leafhopper injury as one possible cause of clover and alfalfa failures, a problem which that department has under study.

hopper, *Empoasca fabae*. This leafhopper was found by E. D. Ball, in 1919, to be the cause of a tip and marginal burning of potato leaves. The similarity between the symptoms observed on the clover plants and those described as hopper burn on potatoes led these workers to believe that tip and marginal burning of the leaves of clover and potatoes was due to the same cause. This was found to be the case by experimentation the same season. C. V. Piper, in 1914, noted that a "species of leaf-



1. Pronotum
2. Scutellum

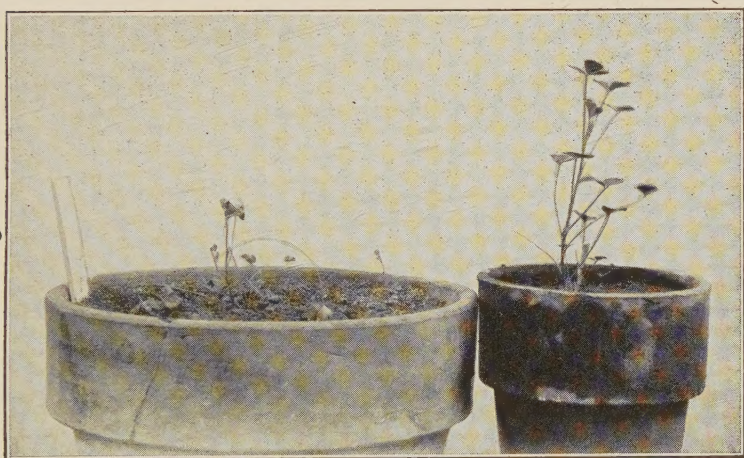
The adult leafhopper (*Empoasca fabae*) enlarged. Its length is about one-eighth of an inch.

hopper seems to be constantly associated with alfalfa yellows." This relation of leafhopper to alfalfa yellows was not demonstrated experimentally until 1926 when Fred R. Jones and A. A. Granovsky found that *Empoasca fabae* was the cause of "yellows" or "yellow top" of alfalfa.

CHARACTER AND EXTENT OF THE INJURY

The injury to the leaves of clover consists of a tip and marginal browning where the tissue has been killed. The tip burn is generally V-shaped with the apex of the V on the mid-vein. Brown areas may occur on the margin of the leaf when

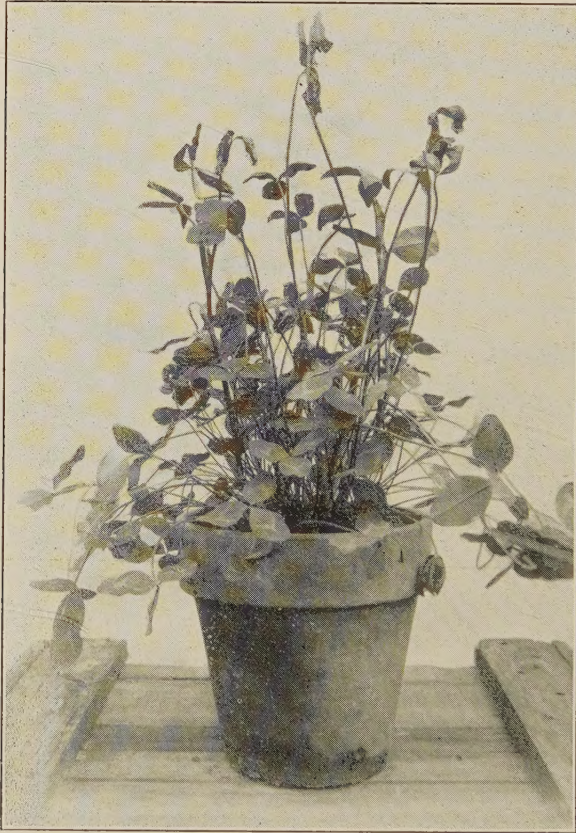
the entire margin is not affected. Sometimes the entire leaf wilts and bends down and later becomes brown and brittle. The sudden wilting and bending of the leaf is most noticeable with young, tender plants. Sometimes the stems become twisted or distorted. Frequently the leaves become yellowed or there is a distinct diffused yellowing along the mid-vein; also, the leaves sometimes take on a reddish, purplish, bronzy or pinkish cast. The tender leaves of alfalfa and the ends of branches sometimes



The alfalfa plant with the wilted leaves was injured by a single female leafhopper which fed on the plant from June 4 to June 11, the other plant was free of leafhoppers.

wilt and bend over and die. Leaves become yellowish and have a bronzy or purplish cast. The first symptoms of injury may appear within twenty-four hours after the plants are attacked, which is the case with both clover and alfalfa. Young clover and alfalfa plants are more severely injured than are old plants and may die from the feeding effects of the hoppers. The foreign clovers are more severely injured than are the native clovers. Infested clover and alfalfa make much less growth than uninfested plants and can be detected by their dwarfed appearance. The infested plants go into the winter season weakened and with reduced root systems and

it is believed that the plants are more subject to winter injury for that reason. The failure of clovers due to their dying during mid-season or a little later can probably be attributed, to a very great extent, to the injurious effects of the feeding of the leafhoppers.

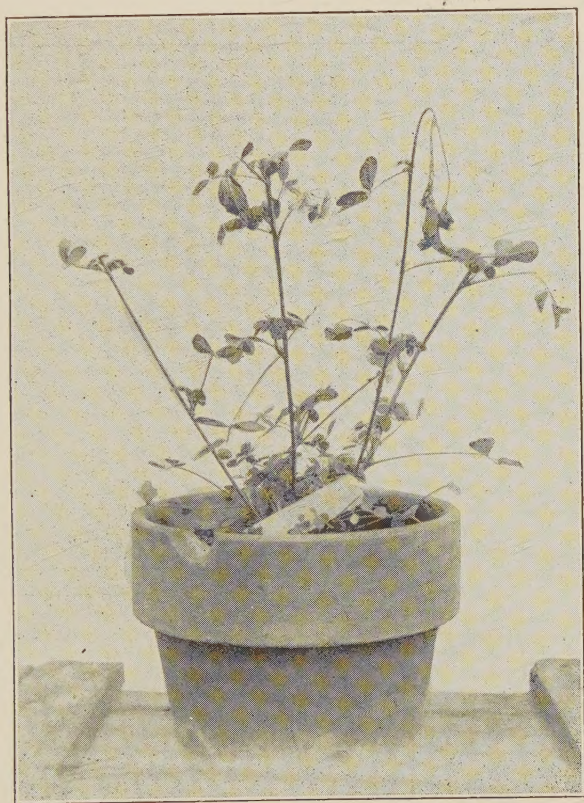


A clover plant showing several wilted and partly dried leaves. Sixteen female leafhoppers were placed on the plant on May 29 and were removed on June 11.

DESCRIPTION OF THE INSECT

The leafhopper is a slender, pale green insect about one-eighth of an inch long. The mature adults have white marks on

the vertex and face, a row of about eight spots on the front of the pronotum and a broad H on the scutellum. The adults are active and fly when disturbed. The young hoppers, or nymphs, are light green and wingless and when disturbed run with a sidewise movement across the leaf. The older nymphs may

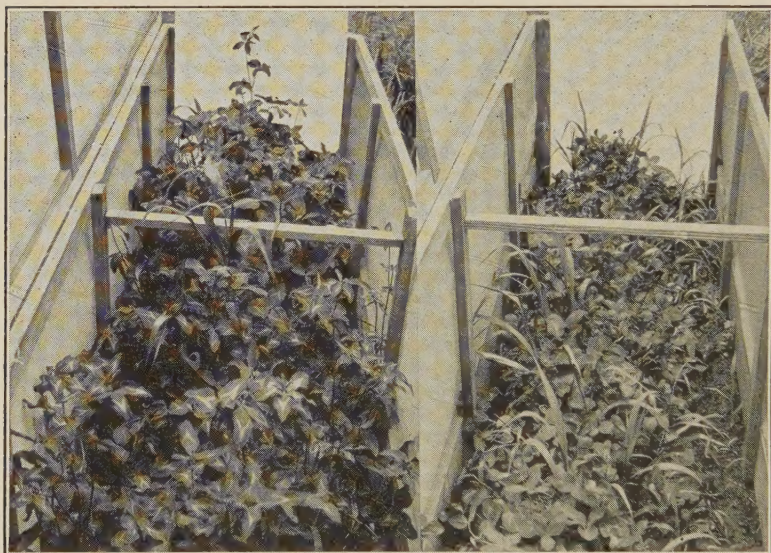


An alfalfa plant injured by the feeding of 24 female leafhoppers from May 29 to June 11. A tip of one branch and several leaves were killed.

jump when disturbed. The nymphs live on the under side of the leaves. Both adults and nymphs have beaks for piercing the tissue of the plants and sucking the juices.

LEAFHOPPER CONDITIONS IN 1928

The leafhopper, *Empoasca fabae*, is at times quite abundant in Kentucky and is most frequently noticed because of its attacks on potatoes. As an enemy of clover and alfalfa, this insect assumes a position of greater importance because of the economic importance of these crops. Leafhoppers were not abundant in the field during the summer season of 1928 and as a result there



Kentucky red clover, Ky. 1, of the same age; at the left uninfested by leafhoppers, at the right infested by leafhoppers. The photograph of the clover used in Test 17 was taken July 12.

was very little injury that could be attributed to the hoppers. The adults were collected for the first time on May 21. In case of the spring-sown clover and alfalfa an occasional leaf showed symptoms of hopper injury by the middle of June. There was more evidence of hopper injury as the season advanced but growth of the plant was not greatly affected.

EXPERIMENTS WITH THE LEAFHOPPER (*EMPOASCA FABAE*)
IN 1928

Several tests for the purpose of observing the different symptoms of injury and the effects of the leafhoppers' feeding

on clover and alfalfa were made during the season of 1928. A number of tests were made in the Insectary and in the field and different kinds of clover and alfalfa were used in order to observe the relative resistance to attack, if any, between the different clovers and alfalfas.

The tests in the Insectary were made with potted plants in insect proof cages. The plants in the Insectary were kept free of insects by fumigation with hydrocyanic acid gas before being used in the tests. Each plant, before being used, was carefully examined to see that it was free from insects or diseases. Appropriate check plants were kept under the same conditions as the test plants.

The tests in the field were carried out in cages ten feet long and two feet square at the ends. Each cage had a hinged lid that could be raised during examination of the plants. The seed was sown on the same day in the cages, in rows far enough apart to allow working space between cages. After the seed was sown each cage was fumigated by using calcium cyanide dust under a heavy tarpaulin. Two or three days before the hoppers were introduced into the cages the plants in each cage were dusted with a nicotine dust containing 6 percent of nicotine sulfate by weight and, after the dusting, each cage was covered with a tarpaulin for five minutes to retain the fumes.

EXPERIMENTS IN THE INSECTARY

The tests that were made at the insectary for the purpose of observing the effects of the feeding of the leafhoppers on clover and alfalfa are given in Table 1. Two clovers and two alfalfas were selected for the tests: a Kentucky strain of red clover, Ky. 1*, Italian red clover†, common alfalfa and Peruvian alfalfa. In all the tests where female hoppers were placed on the plants, except test 14, nymphs appeared after about two weeks.

*Agronomy Department test number.

†Seed furnished the Agronomy Department by the Bureau of Plant Industry, U. S. Department of Agriculture.

TABLE 1. TESTS IN THE INSECTARY

Test	Plant	Height of Plant Inches	No. and Stages of Insect	Placed on Plant	Removed From Plant	Injury First Observed
1	Ky. 1	10	20 females, 2 males	May 21	May 28	May 28
2	Ky. 1	10	16 females	May 27	June 11	June 4
3	Ky. 1	10	17 females	May 30	June 9	June 6
4	Ky. 1	6	5 nymphs	June 15	June 21	June 18
5	Ky. 1	3	1 nymph	June 22	June 25	July 2
6	Italian	10	20 females, 2 males	May 21	May 28	May 28
7	Italian	10	17 females	May 30	June 9	June 4
8	Italian	10	20 nymphs	June 21	June 29	June 24
9	Italian	3	1 nymph	June 22	July 2	June 25
10	Com. Alf.	10	20 females, 2 males	May 22	May 29	May 23
11	Com. Alf.	12	24 females	May 29	June 4	May 29
12	Com. Alf.	12	19 males	May 30	June 11	June 9
13	Com. Alf.	3	3 nymphs	June 6	June 21	June 9
14	Per. Alf.	3	3 females	June 9	June 13	June 11
15	Per. Alf.	3	3 nymphs	June 15	June 21	June 18
16	Per. Alf.	6	1 female	June 21	June 27	June 25

The first indication of injury was a wilting of leaves and of the tender tips of branches. This sometimes took place the same day the hoppers were placed on the plants. The wilted leaves and tips of branches generally became dry and brittle within three or four days. There was more wilting of the leaves in case of the Italian clover than with Kentucky clover. Many leaves of both clovers became yellowed or browned or partly browned and some took on a purplish cast. The Italian clover, generally, was more severely injured than the Kentucky clover. A statement of the condition of the plants at the final examination is given below.



Italian red clover of the same age; at the left uninfested by leafhoppers, at the right infested by leafhoppers. The photograph of the clover used in Test 18 was taken July 12.

CONDITION OF CLOVERS

Test I. The plant was examined for the last time on June 20 when 26 percent of the leaves were dead and 36 percent showed injuries. Test 2. All the leaves of the plants were dead on July 5. Test 3. The plant was examined June 25 and 39

percent of the leaves were dead and the rest showed injuries of various kinds. Test 4. The two plants used in the test were dead on July 5. Test 5. The three leaves of the plant were wilted and partly browned on July 2. Test 6. At the final examination on June 20, 30 percent of the leaves were dead and 50 percent showed various injuries. Test 7. The plant was nearly dead on June 25 when 79 percent of the leaves were dead and the rest were injured. Test 8. Plant was examined last on June 29 when 8 percent of the leaves were dead and 25 percent showed various injuries. Test 9. The leaves of the two plants used in the test were all wilted and dying on July 2 when examined last.

CONDITION OF THE ALFALFAS

Test 10. The leaves on the plant used in this test were decidedly yellowed on June 4 and by June 21 all the leaves and stems were dead. Test 11. The plant used in this test was severely injured by June 15 when the tips of several branches were dead, many of the leaves shriveled and some slightly yellowed. By June 21, only parts of the stems were alive. Test 12. In this test where males only were used, the plant showed considerable injury by June 15, some of the leaves were yellowed, others shriveled and the tips of some of the branches were dead. Test 13. All the leaves of the two plants used in this test were completely wilted on June 21 and by June 29 both plants were dead. Tests 14 and 15. The four plants used in test 14 and the two plants used in test 15 were dead when examined June 27. Test 16. The tips of the branches and many of the leaves of the three plants used in this test were wilted on June 25. The plants were cut off near the soil on June 28 and they all put out new leaves later in the season.

EXPERIMENTS IN THE FIELD

In the experiments in the field, the following clovers and alfalfas were used: Kentucky red clover, Ky. 1, Italian red clover, French red clover, alsike clover, white clover, Ontario variegated alfalfa, common alfalfa, Utah Grimm alfalfa, and Utah Cossack alfalfa. The several tests are arranged in Table 2. The hoppers were used in the proportion of 85 females to 15 males.

TABLE 2. FIELD TESTS.

Test	Plant	Height of Plants Inches	No. of Hoppers in Cage	Date Placed in Cage	Height When Cut, inches		Date When Cut	Weight When Dried	
					Infested	Check		Infested Grams	Check Grams
17	Kv. 1	6	100	June 7	10	20	July 17	195	395
18	Italian	6	100	June 7	6	22	July 17	15	444
19	French	6	100	June 7	8	20	July 17	76	403
20	Alsike	5	100	June 12	8	18	July 17	26	365
21	White	4	100	June 12	5	12	July 17	18	203
22	Ont. Var. Alf.	12	100	June 12	18	24	July 18	140	400
23	Com. Alf.	12	100	June 13	20	24	July 18	165	413
24	Utah Grimm Alf.	10	100	June 14	12	24	July 18	122	410
25	Utah Cos. Alf.	10	100	June 14	12	24	July 18	165	580

In all the tests, the infested clovers and alfalfas were severely injured. The injured leaves of the clovers sometimes wilted and died or they became yellowed or browned or they took on a pinkish, purplish, reddish or bronzy cast. The injured leaves of the alfalfas wilted and died or became yellowed and sometimes had a purplish cast. Some of the tips of branches of the alfalfas wilted and died and many of the infested plants in all the tests died, but the number varied very greatly for the



French red clover of the same age; at the left uninfested by leafhoppers, at the right infested by leafhoppers. The photograph of the clover used in Test 19 was taken July 12.

different tests. The infested clover and alfalfas made much less growth than the uninfested plants; in fact, the infested plants in some of the tests were very little taller at the time they were cut than at the time the hoppers were introduced into the cages. The growth of the infested plants after they were cut was much less than that of their checks.

The Kentucky red clover was the least injured of any of the clovers used in the tests. Its growth was thicker than that of

any of the other clovers and at cutting time was about half as tall as its check and weighed about half as much as the check. Very few plants died during the season. The Italian clover was injured more severely than any of the other clovers and at cutting time practically all the leaves were dead. Very few of the plants recovered after they were cut off. The French clover was also very severely injured and about seventy-five percent of the leaves were dead at cutting time. The plants made a good recovery, however, later in the season, but the stand in the row was thinner than at the beginning of the test. The alsike clover was injured about as severely as the Italian clover. Very few plants recovered after they were cut off and those that did recover made a very weak growth. The white clover (Little Dutch) was injured severely in the early part of the season, but grew well during the later part of the season.

The four alfalfas used in the tests were all injured by the hoppers. The common alfalfa was the least affected by the hoppers but was reduced in weight to 40 percent of its check and, after it was cut, made the best growth of any of the alfalfas. The Ontario variegated alfalfa was injured to only a slightly greater extent than the common alfalfa. The Utah Grimm and Utah Cossack alfalfas were both severely injured by the leafhoppers and made less growth than either the Ontario variegated or common alfalfa. Plants of all the alfalfas died from the effects of the feeding of the hoppers, but more plants of the Utah Grimm and the Utah Cossack alfalfas died than of the common and Ontario variegated alfalfas.

The growth of the infested clover and alfalfa during the month of August and early fall was much less than that of the uninfested plants. The plants were weaker and ranged in height from one-third to one-half as much as their checks.

HOST PREFERENCES

From the tests made during the season of 1928, it is evident that the foreign clovers were more severely injured by the leafhopper than was the Kentucky red clover. In these tests there was no mixture of native or foreign clovers so that it was not

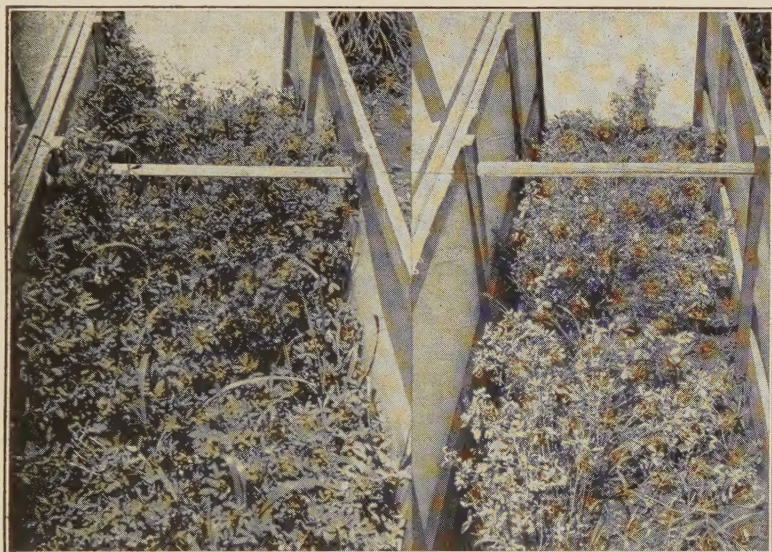
determined whether there was tendency on the part of the hoppers to select one kind of clover in preference to another as host plants. In the field, where there were a number of different collections of clovers in adjoining plots, it was found that in three out of four different collections of hoppers made at different times, there were more hoppers on a foreign clover. The collections were made by sweeping the plots in as nearly the same manner as possible on each plot. While this method is not an accurate



Alsike clover of the same age; at the left uninfested by leafhoppers, at the right infested by leafhoppers. The photograph of the clover used in Test 20 was taken July 12.

method of getting counts, it may well indicate degrees of infestation. Two clovers were used for sweeping, a Tennessee red clover and Italian red clover. The collections made on July 10 showed 1.4 times as many hoppers on the Italian clover as on the Tennessee clover. The collections made on August 17 showed 2.9 times as many hoppers on the Italian clover as on the Tennessee clover and the collections made on September 10 showed 2.4 times as many hoppers on the Italian as on the Tennessee clover. The col-

lections on September 17, however, showed reversed conditions when 2.8 times as many hoppers were found on the native red clover as on the Italian clover. It was noticed, however, that the Italian clover was in poor condition as compared with the



Utah Grimm alfalfa of the same age; at the left uninfested by leafhoppers, at the right infested by leafhoppers. The photograph of the alfalfa used in Test 24 was taken July 14.

Tennessee clover, there being a considerable amount of dead foliage on the Italian clover which very likely made it less attractive than the Tennessee clover.

RELATION OF THE LEAFHOPPER TO CLOVER FAILURE

Failure or partial failure of clover is not an uncommon occurrence in Kentucky, and apparently the same situation with regard to alfalfa is developing, especially in the older alfalfa-growing sections of the State. In those failures which occur or have their beginnings during midsummer or a little later, especially on good soils, the leafhopper (*Empoasca fabae*) may often be the causal agent. It appears, therefore, that the in-

juries to clover and alfalfa caused by this leafhopper must be regarded as another cause of the failure experienced with these crops. Usually, under field conditions, the injury from leafhoppers is not severe enough to cause the death of the plants before winter, but leaves them in a weak condition. A distinction must be noted, however, as regards the extent of injury caused to the clovers from different regions. The Italian suffered most, French next, and Kentucky least. This is the same order as that found by the Agronomy Department for winter injury to these clovers.* Consequently, it appears that the differences in injury from the leafhopper may account, in part at least, for the differences in winter hardiness which that Department has found to exist between red clover of different origins; differences upon which it bases, in part, its reasons for advocating the use of adapted home-grown red clover seed.

SUMMARY

The leafhopper, *Empoasca fabae*, because of its feeding upon clovers and alfalfa, does great damage to these plants. A single adult or nymph may cause the death of young plants.

The injury is made manifest by the wilting of leaves and tips of stems, the discoloring of leaves, dwarfing of the plants and dying of parts of plants or the plants themselves.

The plants are most severely injured at about midseason or a little later, because the leafhoppers are more numerous at this time.

It appears that leafhopper injuries to clover and alfalfa must be regarded as another cause, direct or indirect, of the failure of these crops.

Foreign clovers are affected by the feeding of the leafhopper to a greater extent than are native strains of clovers, but the Italian red clover was more severely injured than the French red clover.

The Kentucky strain of red clover, Ky. 1, was the least injured of any of the clovers used in the tests.

*For a fuller discussion of the winter-hardiness of various clovers the reader is referred to a report now in preparation by the Agronomy Department for publication as a Station bulletin.

